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DRY FARMING IN WESTERN SOUTH DAKOTA

GRAIN CROPS in western South Dakota, in the average results of a series of years, show yields that should be profitable, but the averages are made up of heavy yields in some years and low yields or failures in other years rather than fairly good yields each year. This indicates an unstable condition of grain farming.

The investigations of the United States Department of Agriculture at the Belle Fourche Field Station, near Newell, since 1908, and at the United States Dry Land Field Station, Ardmore, since 1912, show that the sureness of grain production can be considerably increased by the use of summer-fallow. With modern machinery, efficient management, and normal prices, conditions appear favorable to the success of large-scale grain production by mechanized agriculture.

Summer-fallow as a preparation for small grains in this section, however, has a strong competitor in cultivated feed crops, the most important of which is corn. Livestock is necessary to the utilization of such crops. For the majority of farmers a combination of crop growing with livestock production promises to form the basis of a stable system of farming for western South Dakota.

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DRY FARMING IN WESTERN SOUTH DAKOTA

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AGRICULTURAL CONDITIONS

WESTERN SOUTH DAKOTA is largely a dry-farming country. With the exception of the Black Hills and a narrow belt of land adjacent to and influenced by them, it lies within a region normally deficient in rainfall. A certain part of this territory is irrigated, and more will no doubt eventually be reclaimed, but most of it must always be dry farmed.

Attempts to make this part of South Dakota a strictly crop-producing section have been unsuccessful. Settlement in this country generally was made after a series of good years had created an exaggerated idea of its crop possibilities. Only those settlers who turned to the raising of livestock as their principal industry were able to remain.

Developments in farm equipment during the last decade have made it possible for one man to handle a large acreage of ground, and have made crop production relatively more important than it was a few years ago. In spite of this fact, crop production alone offers a possibility of success only under the most efficient type of management. The production of livestock remains the basic industry of the section. The best development of the livestock industry requires the growth of a certain proportion of crops. This bulletin, in reporting the results of studies of methods of crop production, indicates a way in which the two enterprises may be combined and each made more successful. In addition, it indicates a way in which crop production alone may be made more stable. The recommendations are based upon results obtained on the dry-farming unit of the Belle Fourche Field Station, near Newell, S.Dak., established in 1908, and on those of the United States Dry Land Field Station at Ardmore, established in 1912. At both stations all the adapted crops have been under trial each year under all the combinations and methods that appear likely to be practiced or to offer a possibility of success.

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TOPOGRAPHY

Most of western South Dakota is a Plains section. There are portions too rough for cultivation, but by far the larger part is physically suited to crop raising. Much of it consists of rolling hills whose slopes are generally not too steep to be cultivated. Economic conditions that decide how much of the land can be profitably cultivated, rather than the topography of the country, will determine the area of land devoted to crops.

SOILS

The soils of western South Dakota range from almost pure sand to a very heavy clay, or gumbo. The Pierre clay, or gumbo, soil constitutes about one third of the area of South Dakota west of the Missouri River. The station near Newell is situated on this type of soil, and the results at this station apply particularly to it. On soil of this type dry farming is most difficult and crop production least successful. Both the expense of working the soil and the fact that crops show less drought endurance on this heavy soil than on lighter soils contribute to this result. So far as soil conditions are concerned, the lighter the soil the more certain crop production should be, provided the soil is not so light that it blows. The lighter soil probably will not produce yields as high as those on the heavy soil in favorable years, but will endure more drought and produce better yields in years of partial failure. Average yields obtained at Newell are doubtless lower than would be obtained on more favorable soils in western South Dakota.

The station at Ardmore is located in a soil of heavy clay type, but deeper and somewhat lighter than the gumbo of the station near Newell.

CLIMATE

The average annual precipitation in western South Dakota, exclusive of the area influenced by the Black Hills, ranges from 13 to 18 inches. At both Newell and Ardmore about two thirds of the total precipitation, which averages about 16⅓ inches at each place, occurs during the 5 months from April to August, inclusive.

Only in exceptional years is the precipitation high enough and sufficiently well distributed to allow all crops to mature without having their growth checked to some extent by drought. Likewise it is rare for any year to be so dry that all crops fail completely.

In most years there is drought injury, varying in extent with the amount and distribution of the precipitation and with the intensity of other climatic factors. This injury seldom affects all crops equally. Small grains, which make their growth early in the season, may completely fail in a year when late-growing cultivated crops make good yields, or a good yield of small grain may be obtained in a year when cultivated crops do not produce well.

The distribution of rain through the growing season is usually the deciding factor in determining which crops will be successful in any given year. Because one crop may do well in a year when another crop fails, some diversification of crops is desirable.

CROP PRODUCTION

Water stored in the soil at seeding time is used by the crops, and, so far as it is needed and is able to supplement the rainfall, may determine the yield. In this region, however, such moisture alone is not sufficient to produce crops. Production depends upon the rainfall during the season in which the crops are growing.

Therefore, except for winter wheat, the choice of crops in any given year should not be influenced to any great extent by conditions before seeding. The best practice is to select crops that have shown the best average results for a number of years and to devote a certain area of land to these each year, rather than to try to base the acreage to be devoted to crops and the kind of crops to be grown upon conditions prevailing before seeding time in any particular year.

Successful crop production in western South Dakota must embody the following principles: (1) The selection of crops best adapted to the locality and the best varieties of these crops, (2) the use of cultural methods that will give the greatest return for labor in the production of these adapted crops.

ADAPTED CROPS

The crops adapted to western South Dakota are principally small grains, cultivated crops, and pasture and hay crops.

SMALL GRAINS

Production of small grains at both stations has been uncertain in the extreme, though in the average of a series of years most grain crops have shown satisfactory yields. The fairly good average yields represent high yields in good years and low yields in other years, rather than fairly good yields each year.

The longest period during which good yields were obtained each year was at the Belle Fourche Field Station during the years from 1922 to 1930, inclusive. The most extended period of nearly complete failures due to drought was at the same station during the years 1910, 1911, and 1912.

The average yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the two stations are shown in table 1. The yields given in this table are the averages of all methods under trial, and for most crops they represent an approximately equal number of the better and the poorer yielding methods. They are probably above the averages obtained by all farmers, but it should be possible for farmers using only the best methods to equal or exceed them.

The yearly results in table 1 show why grain farming alone has resulted in so many failures in this section. If it were possible to produce each year a yield of wheat nearly equal to the average, without doubt wheat raising would have been a profitable type of farming. The fact that yields may be very high or very low has made wheat production very unstable. In the past, several successive years of failure or near failure in the wheat crop usually resulted in impoverishing the farmers depending upon wheat alone to such an extent that they were forced to leave the land or

to reduce their operations so much that they were unable to profit during the succeeding good years. Farmers whose livestock provided some income during poor crop years were able to continue.

TABLE 1.—*Yields of winter wheat, spring wheat, oats, barley, corn, and sorgo at the Belle Fourche Field Station, Newell, S.Dak., and the United States Dry Land Field Station, Ardmore, S.Dak., for certain years in the 22-year period from 1909 to 1930*

Station and year	Winter wheat	Spring wheat	Oats	Barley	Corn		Sorgo, total
					Grain	Stover	
Newell:	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Bushels*	*Pounds*	*Pounds*
1909	28.9	28.7	60.9	31.7	19.3	3,305	5,920
1910	1.8	2.6	6.8	3.0	.6	2,839	3,360
1911	0	0	0	0	0	0	0
1912	0	0	8.2	.7	21.9	2,623	4,100
1913	21.3	10.8	23.9	10.1	8.6	986	3,400
1914	18.2	10.1	26.3	9.5	.5	1,115	1,725
1915	36.2	57.6	125.6	72.2	44.5	2,785	6,450
1916	12.7	17.3	33.3	31.0	32.5	2,198	9,650
1917	3.8	7.4	17.1	22.9	20.4	1,969	3,300
1918	27.1	11.9	23.3	14.6	30.0	2,977	7,700
1919	2.0	.9	2.3	1.3	.3	235	0
1920	1.6	29.9	63.8	60.9	37.4	2,008	5,900
1921	5.4	7.3	11.6	12.8	9.0	1,435	2,450
1922	30.8	32.2	66.0	44.8	42.3	3,069	5,950
1923	21.3	28.0	57.5	47.9	52.4	3,379	7,820
1924	30.5	21.5	44.1	28.3	17.7	1,122	3,540
1925	23.6	19.8	52.2	32.3	9.0	1,710	4,640
1926	32.4	31.3	59.7	44.1	33.4	1,852	6,530
1927	11.4	21.6	39.1	13.2	30.3	2,786	7,260
1928	25.8	32.9	66.0	49.3	32.3	1,445	4,690
1929	33.6	28.3	57.0	36.3	28.4	1,624	5,020
1930	19.9	15.4	40.9	32.2	8.4	2,084	5,500
Average	17.7	18.9	40.3	27.2	21.8	1,979	4,768
Ardmore:							
1913	1.4	2.0	2.3	1.4	0	927	----------
1914	0	0	0	0	0	1,013	----------
1915	33.2	46.8	77.2	52.9	38.8	3,669	----------
1916	31.3	21.1	39.8	23.4	22.1	3,025	6,240
1917	7.2	9.2	15.2	5.3	13.9	1,410	3,100
1918	19.4	35.0	65.1	39.9	22.2	2,110	6,700
1919	18.3	11.6	22.4	8.6	9.2	1,524	3,964
1920	25.7	28.1	56.8	35.1	19.3	1,660	4,040
1921	16.0	18.6	42.5	14.4	7.9	1,976	4,290
1922	0	0	0	0	14.8	1,386	4,300
1923	17.4	24.4	59.1	43.5	29.5	2,607	7,180
1924	9.3	11.9	13.3	11.2	2.4	1,978	2,090
1925	[1]10.2	17.1	33.6	32.3	13.0	2,013	3,940
1926	4.4	7.2	24.8	18.6	11.5	1,931	3,900
1927	18.6	32.6	66.8	50.8	36.5	3,442	9,350
1928	20.5	25.5	46.1	27.7	20.4	1,930	3,240
1929	9.4	13.4	25.1	17.9	10.1	2,562	2,560
1930	9.7	10.2	23.1	23.7	3.6	1,105	3,400
Average	14.0	17.5	34.1	22.6	15.3	2,015	4,553

[1] Yield from reseeding to spring wheat.

Wheat raising alone has not been successful in the past, but it can be carried on successfully in connection with livestock production if it is so handled as to require a minimum of labor and expense.

Under exceptionally able management, wheat growing offers a possibility of success on farms where livestock growing is a minor enterprise. Growing wheat under these conditions requires an extensive acreage and management so efficient that expenses are held to a minimum. In this type of farming summer-fallow offers a probability of success, not as a means of increasing the total yields

of a given acreage but as a means of equalizing production among different years and reducing the cost of production.

Oats and barley show the same response to cultural treatments as wheat. The yield of oats in pounds per acre is practically the same as that of wheat at Ardmore and about 200 pounds higher at Newell. Barley has been much more productive than either wheat or oats at both stations. This is not shown in the table of average yields, because a much higher percentage of the barley than of either wheat or oats is grown under poor methods of cultivation. The value of barley is further obscured by the fact that during the first years of the experiments a 6-rowed variety of barley was grown that was much less productive than the 2-rowed variety now grown at both stations. Under comparable methods, the 2-rowed variety of barley has produced an average of about 480 pounds per acre more than oats at Ardmore and 310 pounds per acre more than oats at Newell. Barley is much more valuable in terms of feed produced per acre than any other grain crop.

Winter wheat survives the winter in only a small portion of western South Dakota. When it endures, it may produce a higher yield and be more profitable than spring wheat. When it winter-kills, the land can be reseeded to spring wheat or some other crop without any other expense than seed and seeding. When there is not sufficient moisture in the soil in the fall to insure germination of the seed, planting winter grains is not advisable.

Winter rye has not been so profitable as winter wheat in the section where winter wheat does well. It is, however, more hardy and will endure the winter in any section of the State. Over most of western South Dakota it is generally as profitable as the spring grains. It ripens earlier in the season and consequently often escapes periods of drought that injure spring-seeded crops. For this reason it is a more dependable crop than the spring grains, though its yield does not compare favorably with theirs in years of high production.

The yields of flax at these stations have not been high. Flax has generally been grown as a sod crop on new breaking, and when so grown has given poor yields. Flax on old ground or upon land broken the previous summer has given better results, but even then has not been so good as other grain crops. It is particularly adapted as a cash crop and where a long haul to market is necessary. Its high price in proportion to its bulk makes it a valuable crop under such conditions, even though its weight per acre is relatively less than that of other grains. The chief value of flax lies in its use as a speculative crop on new land.

The recommended varieties of the different crops are: Winter wheat, Kharkof, Turkey; spring wheat, Kubanka, Ceres, Marquis; oats, Gopher, Brunker, Sixty-Day; barley, White Smyrna, Horn, Odessa; and flax, Linota, Bison.

Sow spring wheat, oats, and barley as early as the land can be put in condition. Barley responds to early seeding as much as wheat or oats do. Sow flax from April 15 to May 1. Sow winter grains during the last half of September or the first part of October.

The best rates of seeding are: Spring wheat, 4 pecks per acre; oats and barley, 5 to 6 pecks per acre; winter wheat, 3 to 4 pecks per acre; and flax, 20 to 30 pounds per acre.

CULTIVATED CROPS

The cultivated crop grown most generally in western South Dakota is corn. There are varieties that will ripen in all parts of this section. A yield of grain cannot be obtained every year, but a yield of fodder is fairly certain. Sorgo is the only other crop likely to compete with corn as a coarse-feed crop in this section. Table 1 shows that corn has produced a good crop of grain in about half the years at each station. At Ardmore there has been some crop, at least of stover, every year, but at Newell there was complete failure in 1911 and failure under most methods in 1919. In both years the ground was so dry at corn-planting time that the seed did not germinate. For the same reason sorgo failed in those years at Newell.

The greatest value of corn as a dry-land crop is in its ability to produce a fair yield of stover even in dry years. Corn fits in admirably with livestock raising and can be depended upon to produce winter feed for stock in most years so dry that the growth of grass on the prairie is scant and little hay can be cut. In addition, corn produces a fairly good yield of grain in more favorable years. The combined value of the grain and stover tends to make it the most profitable dry-land crop in this area. As the number of stock in the section increases and the area in which hay can be cut becomes smaller, farmers will be more and more dependent for their winter feed upon crops like corn that produce a large yield of rough feed per acre.

The adaptation of corn varies with the type of soil. In general, yields have been higher and more certain on lighter soils than on soils of heavy types like those at the two stations.

Sorgo produces a higher yield of stover per acre than corn over most of western South Dakota, and the stover is more palatable. The combined value of the grain and stover of corn is greater than the stover value of sorgo. This, together with the fact that corn is easier to produce, makes it seem certain that corn will continue to be the leading cultivated crop. However, in a considerable number of years when the yield of ear corn was low at both stations, the yield of sorgo was proportionately greater than in more favorable years. A portion of the corn acreage could well be replaced by sorgo as an insurance against failure of the feed crop in unfavorable years. Sorgo fits into a rotation as well as corn and has proved valuable as a winter feed for steers as well as for horses and young stock.

The varieties of corn best suited to western South Dakota differ with the localities. Near the northern part of the State only very early corn will mature. In the central and southern portions the earlier dent corns, such as Northwestern and Payne White, have been most successful. In many places some unnamed varieties have been grown in restricted localities for a number of years. In most cases adapted acclimated varieties like these are as valuable as the standard varieties that are more widely known.

Only the sweet sorghums are adapted for growth as far north as South Dakota. Minnesota Amber, Dakota Amber, and Red Amber are the most promising varieties.

PASTURE AND HAY CROPS

The principal pasture in western South Dakota is the native sod. The cultivated crop most extensively used is alfalfa. This has proved valuable for hog pasture, though under even the best systems of pasturing there may be times in the summer when it produces no feed. Crested wheatgrass and bromegrass have possibilities as early pasture. Both make a very early growth and can be pastured heavily before native grasses are well started. Both cease growth and become hard and woody during the summer. Their greatest value lies in their ability to produce a large amount of early pasture. A small acreage of either could be used to supplement the native pasture. At Ardmore crested wheatgrass has shown a higher carrying capacity than bromegrass.

Alfalfa is the principal cultivated hay crop, though bromegrass and crested wheatgrass offer possibilities. Their yield of feed per acre is much less than that of corn and similar crops, but there is an advantage in that they do not need to be planted each year. Alfalfa at least will endure for an indefinite number of years. It will produce a cutting practically every year, though the growth may often be checked by drought before the alfalfa comes into bloom. In some years two cuttings and occasionally three cuttings will be obtained.

Alfalfa is particularly adapted for growth along streams or on bottom lands where the ground water is within reach of the roots. Under conditions like these it will make two or three cuttings each year. Bromegrass and crested wheatgrass produce one cutting of hay in most years. Even under the best conditions, however, these crops will not exceed alfalfa in average production.

In addition to its value as a forage crop, alfalfa often has great value as a seed crop. In years when seed production is good, the value of the seed is usually far greater than that of the forage.

The ability of alfalfa to produce seed depends to a great extent upon the type of soil upon which it is grown. On the heavy clay soils, like that at Newell, alfalfa seldom produces seed after it has once been established, even when grown in cultivated rows. The plant generally begins to suffer from drought before it comes into full bloom and little seed is formed. On lighter soils alfalfa suffers less severely from drought and produces seed in most years if it is grown in cultivated rows or broadcast with a very thin stand. Culture in rows is the surest method of producing seed, but the expense of cultivation somewhat reduces the profit under this method. Practically the same forage yield is secured from alfalfa in cultivated rows and from that sown broadcast.

Where ground water is within reach of the roots a seed crop is obtained nearly every year, and there is no advantage in growing alfalfa in cultivated rows. Either the first or the second cutting may be left for seed.

Except where the ground water can be reached by the roots, alfalfa-seed production is not sufficiently certain to become a part of any definite farming system. However, on the lighter soils of western South Dakota a certain part of the land can very advantageously be planted to alfalfa. In years of good seed production the

alfalfa can be saved for seed. In years when it seems apparent that little seed will be formed, the crop can be cut for hay.

The variegated alfalfas—Grimm, Baltic, and Cossack—have shown slightly better yields and greater hardiness than common alfalfa.

CULTURAL METHODS

The number of tillage operations required in preparing the land for a crop differs a great deal with different cultural methods. The times at which the labor must be performed likewise differ. The tillage operations involved in each method of cultivation and the time at which they may best be performed are:

Spring plowing for all small grain should be done as early as weather conditions will permit. Plowing to a depth of 4 to 6 inches is advisable. The land should be disked before it has a chance to dry out, and harrowed at least once after plowing. Spring plowing for corn may be delayed until after small grains are seeded.

Fall plowing may be done any time after harvest. From 5 to 8 inches is a good depth. As the land is usually dry in the fall, it is best to leave it rough until spring. A double disking and a harrowing in the spring are all the preparation necessary before seeding small grains. Where a later-seeded crop is to be planted, additional cultivation may be required to keep the land free from weeds until seeding. Fall plowing provides a better distribution of labor than spring plowing.

Disking without plowing, at both stations, has been practiced only for small grains. On land where an intertilled crop has been grown, double disking and sometimes harrowing are all the preparation required before seeding.

Listing for small grains may be done any time after harvest. The lister should be run a little deeper than for planting corn, and the furrows should be about the same distance apart as for corn. The land may be left rough over winter and worked down level in the spring. Normally, two diskings and a harrowing are required. Listing for corn is usually done with a lister planter. No cultivation before planting is required if corn is planted in this manner.

Subsoiling is done at the same time as fall plowing. The land is plowed with an ordinary plow to a depth of 8 inches, and a subsoil plow is run in alternate furrows to an additional depth of 8 inches. As the time and labor necessary for plowing with the subsoil plow are at least as great as for original plowing, the cost of the whole operation is practically that of two plowings. The spring cultivation needed for subsoiled land is the same as for land given an ordinary fall plowing.

Land to be summer-fallowed should be plowed about 8 inches deep during the latter part of May. It may be given a light harrowing immediately after plowing, or it may be left rough until weeds commence to grow. It should be cultivated often enough to keep it clean. The use of some implement, such as the duckfoot cultivator, that destroys weeds but leaves the ground in a lumpy condition is desirable. The lumpy condition facilitates the penetration of water and protects against soil blowing. Usually three cultivations keep the land free from weeds during the entire summer, though the

number required to do this differs with the season. Timeliness is very important, since weeds are more easily destroyed when they are small. Fallow requires the use of the land for 2 years to produce one crop and consequently is expensive. This operates against its use where land is high priced or acreages are limited.

Green manuring is the most expensive method that has been tried. It involves the preparation of land for the green-manure crop, the cost of seed and seeding, the plowing under of the green-manure crop, and keeping the land free from weeds the rest of the season. Usually 2 plowings, at least 2 diskings, and 2 or more harrowings are required. The loss of the land for a year is also an item of expense in preparing land by this method.

SMALL GRAINS

Results at both stations indicate clearly that the most profitable crops of grain are produced by the cheaper methods of soil preparation. Grain on disked cornland or on disked land where some other cultivated crop has been grown has shown the highest net return under any method of soil preparation that has been tried. This is due largely to the low cost of production, but partly to the fact that disked cultivated land has generally produced yields above the average. The yields of wheat, oats, and barley on disked cornland have been higher than the yields of the same crops on spring-plowed or fall-plowed cornland. It must be borne in mind that the corn ground had been kept free from weeds. If weeds had been allowed to grow, the results probably would not have been so favorable. If the corn ground is kept clean, producing grain on the disked cornland is by far the most profitable method that has been tested.

Spring plowing and fall plowing are about equally desirable as methods of land preparation for grain. Practically the same amount of labor is necessary in preparing a seed bed under each method, and when seeding is done at the same time the yields produced are nearly the same. Fall plowing can be done at a time when work is not so pressing and has an advantage over spring plowing in that respect. Since seeding can be started as early as plowing, fall-plowed land can be seeded earlier than land that must be plowed in the spring. This fact becomes most important in seasons when unfavorable weather conditions hinder spring work, and provides a decided advantage for fall plowing, because early seeded crops mature earlier and as a result often escape periods of drought that injure later seeded crops. However, the land is usually dry after harvest, and, unless there are fall rains, the soil may be so hard and dry that the cost of fall plowing is prohibitive. When this is the case plowing in the early spring assures returns as good as if the land had been plowed in the fall, if seeding is not unduly delayed. Grain on early fall plowing generally makes a better early start than grain on spring plowing, but in years of drought this frequently is responsible for earlier firing of the grain on fall-plowed land.

Where land is cheap, disking in one crop of small grain on grain stubble is frequently advisable. Disking in grain continuously for a number of years results almost inevitably in a great increase in the number of weeds and a consequent reduction in yield.

Plowing is more expensive than disking in preparing land for grains. When small grain follows corn, better crops are obtained by disking. In the sections of western South Dakota where grain growing is most successful and where the quantity of grain to be grown greatly exceeds the area of cultivated crops, plowing part of the grain stubble for grain is recommended. The use of power in farming and the consequent increase in the cultivated acreage have generally increased the proportion of grain that must be planted following grain.

The yields of small grain on listed land compare favorably with those on plowed land. The cost of producing a crop on listed land is slightly lower, and the net return is a little higher. The difference in return is not great enough to justify the purchase of any special equipment for growing grain on listed land. Noxious weeds appear to become established on listed land more readily than under other methods of cultivation, and no doubt would eventually cut yields down.

Summer-fallowing has not increased the total yield of crops, but its use has resulted in a better distribution of yield among years. When machinery was horse drawn, the fallow was not advocated because of its greater expense. Power farming has brought about two changes that tend to make fallowing more practicable. The first is the material reduction in the cost of keeping land fallow. The second is the fact that greater acreages can be handled, and the proportion of grain to livestock has become higher. Fallow has a place in the cropping system on many farms as a possible insurance against failure and as a method of controlling weeds. It cannot be used profitably on farms where a large number of livestock are carried. It is of value on farms where grain growing is the chief enterprise and where, without fallow, a large percentage of the grain acreage would follow grain. Fallow, if used, should replace a portion of the grain following grain. When so used, fallow tends to stabilize production, as is shown in the results at the two stations.

At the station at Newell there were 2 years from 1909 to 1930 in which wheat under all methods of tillage was a total failure because of drought. There were only 2 other years in 22 in which the yield on fallow fell below 10 bushels per acre, but wheat after wheat fell below 10 bushels 8 times. Oats on fallow fell below 20 bushels in only 4 out of 22 years. Oats following oats yielded less than 20 bushels in 8 of the 22 years. Barley yielded less than 15 bushels 5 times on fallow and 9 times on continuous cropping.

At Ardmore, excluding the 2 years when the entire crop was destroyed by hail, there was only 1 year from 1913 to 1930 in which the yield of wheat on fallow fell below 10 bushels per acre. During the same period wheat after wheat fell below 10 bushels per acre in 9 of the 16 years. Oats on fallow fell below 20 bushels per acre in 2 of the 16 years. Oats after oats yielded less than 20 bushels in 9 of the 16 years. Barley on fallow fell below 15 bushels per acre in 3 of the 16 years. Barley after barley produced yields of less than 15 bushels in 8 of the 16 years. All of the low yields of barley on fallow occurred before the White Smyrna barley was grown in the rotations.

The greater benefit from fallow at Ardmore apparently lies in the fact that the soil at Newell is shallow and not capable of holding as much water as the soil at Ardmore. It is believed that the response to fallow on soils readily penetrated by moisture and roots to a depth of at least 4 feet would be as great in the section represented by Newell as at Ardmore.

The use of green-manure crops has not been profitable in grain production and is not recommended for any section of South Dakota. The yields have generally been lower than those on fallowed land, and the cost of production has been higher.

Subsoiling and deep tillage have neither increased nor decreased yields to a measurable extent. They have added greatly to the cost of production without adding to the value of the crop, and have been less successful than other methods of cultivation. The same labor distributed over more acres would be more profitable.

CULTIVATED CROPS

Spring plowing and fall plowing have given about equal results as methods of soil preparation for corn. Fall plowing requires a little more cultivation, because some spring cultivation is necessary in order to keep the land clean until the corn is planted. It has a slight advantage in that the corn usually comes up a little sooner and matures just a little earlier. There is no great difference in yields, and the cornland may be plowed at any time before planting without the yield being materially affected.

Listing for corn has given lower yields than either spring plowing or fall plowing at both Ardmore and Newell. The lower cost of land preparation, however, makes the net profit per acre nearly as high. In spite of this, listing is not likely to meet with favor in the heavier soils of western South Dakota. The tendency of the soil to crust after heavy rains sometimes results in a loss of stands on listed land. In all cases the corn comes up a little more slowly and matures a little later than on plowed land. For this reason it does not usually suffer so early from drought as under other methods of cultivation, but is less productive in good years. In lighter soils listing is proportionately more effective than on heavy soils and is as profitable or more profitable than plowing for corn.

The more intensive methods of tillage have shown less response with corn than with small grains.

Fall plowing has been superior to spring plowing as a method of land preparation for sorgo. The difference has been largely due to the stand obtained. Spring-plowed land of the heavy clay type cannot always be worked down to form a good seed bed for sorgo, because of its tendency to remain lumpy until mellowed by rains. In seasons that are dry between plowing and planting time, the fine seed bed necessary to give a good stand of sorgo cannot be obtained.

HAY CROPS

Hay crops, such as alfalfa, bromegrass, and crested wheatgrass, are not adapted for use in rotations. They should be seeded in spring or early summer on land plowed in the fall, worked down to form

a solid seed bed in spring, and kept free from weeds until seeding. After a stand of these crops has been obtained, they should remain intact so long as the production remains good. Bromegrass may be pastured to good advantage for several years after it becomes so sod bound that it no longer produces a profitable yield of hay. Crops following alfalfa and bromegrass are usually poor, on account of the extremely dry condition in which the soil is left.

THE BEST SYSTEM OF FARMING

The system of farming that offers the greatest possibility of a permanent agriculture for western South Dakota combines crop production with the raising of livestock. The more certain crops, such as corn stover and sorgo, cannot be grown with profit unless fed near where they are produced. Their bulky nature prevents long hauls, and their sale price is far below their feeding value. The production of livestock alone is likewise subject to limitations, the most important being the question of winter feed. In dry years the growth of grass on the Great Plains is scant, larger acreage is needed for pasture, and the quantity of hay that can be cut is limited. The best way to meet this condition is to grow some annual crop, such as corn or sorgo, that produces a comparatively large bulk of rough feed per acre.

The system of farming that suggests itself is as follows: (1) The production of livestock up to the limit of dry-year pasture, (2) the planting of an acreage of corn sufficient to meet the winter demands of the stock to be carried over, and (3) the production of small grain on the cornland.

The principal limit of livestock production for any one farmer is the area of pasture land he has left after an acreage sufficient for growing crops has been set aside. The number of livestock to be kept should be limited by the extent of pasture available in a dry year rather than that available in a favorable season. It is better to undergraze land in good seasons than to overgraze it in years of drought. The carrying capacity of different sections differs with the native vegetation. The carrying capacity of any particular section must be determined through observation and experience.

Corn stover offers a solution of the question of winter feed. Corn and sorgo can practically be relied upon to furnish the rough feed each year. Ear corn is produced in paying quantities in more than half the years and when obtained can well be utilized either for feed or for sale. Since corn grows well on either spring or fall plowing, the work preparatory to planting can be done at the time when it interferes least with other farm work. The acreage of corn and sorgo grown should be sufficient to insure winter feed for the livestock to be carried over. The acreage should be fixed by the quantity necessary for winter feed in years when the production of stover is not high. In years of extra heavy production the excess feed can be carried over or the number of stock increased for winter feeding.

Small grains can be grown in connection with livestock farming with the chances of success very good and the chance of total failure low. The corn ground provides one of the best-prepared seed beds for small grains, one on which they can be grown at a very low cost.

The land planted to corn one year may be planted to small grain the next, without expense other than for the seed and for disking, harrowing, and seeding. In some years when it seems apparent that no grain will be produced, the small-grain crops may be cut for hay and will provide a supplemental supply of winter feed. This makes the grain crops valuable even in seasons when their production for grain is a failure. As has been stated, the corn should be kept clean. The cost of keeping the corn free from weeds is more than made up in the added value of the crop that follows. The kind of small grain to be raised must depend upon the needs of the individual farmer.

With modifications this system of farming should be adapted to any part of western South Dakota. In most parts of western South Dakota the acreage of small grains may exceed that of corn. The extra acreage of small grains will then be grown on spring-plowed, fall-plowed, or disked grain land. The disking is advocated for heavy land where the cost of plowing is great. Even such land would not be disked unless it were relatively free from weeds. When the land to be seeded to small grains is more than double that planted to a cultivated crop, enough of the small-grain acreage may be replaced by fallow so that small grain will not follow small grain more than one year. Replacing a portion of the grain acreage with fallow offers a better distribution of yield among years, a better distribution of labor, and a more effective control of weeds.

Under highly efficient management grain production alone, on an extensive scale and by mechanized agriculture, offers a possibility of success. Fallow is an integral part of such a system of farming in western South Dakota. The general plan for such a system would be to have a third of the acreage in fallow, a third in grain on fallow, and a third in grain seeded in disked stubble. The fallow would be plowed in May or early June, worked only enough to control weeds, and ridged in the fall at right angles to the prevailing winds to prevent soil blowing.

The climatic records cover a much longer period than those of crop production. They show that years of such extreme conditions as those of 1911 are very infrequent. Such years, as well as those of less extreme conditions like those of 1919, may be provided against in part by a liberal carry-over of surplus feed from years of heavy production. They must be met in part by the importation of feed and in part by the temporary reduction of herds and flocks. The essential thing is that farms must be backed by sufficient capital so that they can stand the strain of such reverses and continue as going concerns prepared to obtain the returns of the good and the average years.

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